Forest Pest Management

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To: District Ranger, Big Valley Ranger District, Modoc National Forest
Subject: Douglas-fir tussock moth outbreak (NE00 - 04)

Summary

The following report summarizes the Douglas-fir tussock moth (DFTM) outbreak that occurred on the Big Valley Ranger District, Modoc National Forest during 1999. The outbreak was discovered during the mid-August mortality surveillance flights. A follow-up flight and ground surveys confirmed defoliation on about 2,200 acres, approximately half was on the Big Valley RD and the other half was on private land. As a result of the defoliation, additional monitoring was conducted to assist in predicting population levels for 2000 in the defoliated and surrounding areas. The results of this sampling indicated that the DFTM outbreak had declined due to natural factors and additional defoliation is not expected in this area this season. It continues to be important for field going personnel to detect tussock moth feeding injury and defoliation to allow for timely decision making.

Background and History

The Douglas-fir tussock moth, *Orgyia pseudotsugata*, (Lepidoptera: Lymantriidae), is a native defoliator of white fir in California. Prior to the outbreak on the Big Valley RD during 1999, there have been six outbreaks of DFTM in California since 1935 (Table 1). Outbreaks tend to occur with little warning and last for three to four years. The primary host for DFTM in California is white fir. Feeding by high densities of larvae can result in tree mortality, top-kill, and growth loss with consequent diverse effects on forested ecosystems and resource management objectives.

One outbreak period (1963-1965) was recorded on the Modoc National Forest prior to this recent one. Light to heavy defoliation of white fir over 20,000 acres was reported near Knox

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Mountain (Rush Creek) during 1963. Light feeding had been reported in this area in 1962. By 1964 there were three infested areas in Modoc County: Knox Mountain (59,730 acres) and Roney Flat (2,280 acres) Big Valley RD, and Stowe Reservoir (470 acres) on the Warner Mtn. RD. At that time, it was the largest recorded outbreak in California history.

First evidence of the tussock moth in the Knox Mountain area was observed in August 1962, while examining a Christmas tree area extensively defoliated by the white fir sawfly. In July 1963, it was noted that while white fir sawfly was the primary insect continuing to defoliate white fir, there was a very significant increase in DFTM larvae. A helicopter flight, conducted in September 1963, to outline possible control project boundaries for the sawfly, indicated that approximately 2,000 acres had varying degrees of defoliation from both insects, with an additional 2,000 acres showing light defoliation by DFTM only. In late June 1964, 2,880 acres of high value Christmas tree property were treated with DDT to control the sawfly. The DDT was also effective against the DFTM larvae. Surveys conducted during the fall of 1963 indicated varying degrees of defoliation by DFTM outside of the treated area. A moderate to heavy population was expected in 1965; therefore, a control project was planned to cover 46,000 acres in the Knox Mountain area. A control block of 3,500 acres and the 2,880 treated in 1964 were excluded from the 1965 DDT treatment.

The Roney Flat infestation was in a mixed fir-ponderosa pine-juniper forest on generally north and east facing slopes. Most of the fir was 10 to 40 ft. in height and open grown. The infestation had caused heavy defoliation in spots in 1964, but a limited sample indicated fairly heavy parasitism of the pupal stage.

The smallest and most intense outbreak occurred around Stowe Reservoir. Heavy defoliation in pure white fir threatened the quality of a newly improved campground and 200 acres were sprayed with malathion during August 1964. The treatment was not efficacious against late instar larvae. In anticipation of high levels of tree mortality the following year, the malathion treatment was followed by a DDT treatment applied over 1,360 acres. Wickman et. al. (1973) reported that the DDT treatment did save foliage, however, tree mortality was the same within the treated area as compared to tree mortality in a nearby untreated infestation.

These outbreaks ended in 1965 under the influence of the chemical treatments and natural control factors. A separate infestation of about 600 acres appeared in 1965 along the Corral Creek Road (Devils Garden RD), but the infestation collapsed due to natural control factors including frost damage to the new foliage in 1966.

Several studies were initiated during the course of these outbreaks to further the knowledge regarding the Douglas-fir tussock moth, its' outbreak cycles, and its effect on tree growth. Copies of several of these publications are available on request at the Susanville FPM office.

DFTM Biology

The Douglas-fir tussock moth has a one year life cycle. Adult males fly from late July to early November depending on weather and location. Adult females have rudimentary wings and do not fly. Females emit a sex attractant (pheromone) that attracts males during their flight period. After mating, the females lay eggs in masses on the foliage, the underside of twigs and branches, on bark surfaces and in bark crevices (Fig. 1). The number of eggs per egg mass is variable,

generally ranging from 100 to 300. The eggs overwinter and hatch the following spring into early summer in general synchrony with host tree shoot elongation. The larvae develop through five or six stages (Fig. 2). The early stage larvae feed on the underside of the current years needles causing them to shrivel and turn brown. Older larvae will feed on both the current year and older foliage often consuming the entire needle. Pupation occurs from late July into August in the same locations as described for the egg masses.

In California, larval emergence generally occurs in mid- to late- June and can extend into July. DFTM larva go through five, six, or occasionally seven developmental stages before pupating (Beckwith 1978a). The larvae feed for about 4 to 10 weeks. The early-stage larvae often produce long silk strands, which help wind-aided dispersal within stands. Larval emergence is usually synchronized with host bud break and shoot expansion. Newly hatched, first and second stage larvae, are only capable of feeding on current year's foliage. The later-stage larvae can feed on older foliage. The final larval instar spins a grayish-brown silken cocoon. In California, pupation can occur from mid-July through September, but may extend into October depending on locality and weather. The pupal stage lasts about 2 weeks.

Adults usually begin to emerge in early- to mid- August and extends into October and sometimes November. The adult male is charcoal gray with feathery antennae and have gray-brown to black forewings with distinct dark transverse markings (Figure 3). In contrast, the adult female has tiny rudimentary wings and thin filamentous antennae. The female cannot fly and usually remains on or near her cocoon to deposit her eggs (Beckwith 1978b).


Figure 1. Egg mass and larvae.


Figure 2. Mature larva.


Figure 3. Adult male.

Outbreak Cycle

In general, outbreaks are relatively short lived and usually decline naturaly within a year or two after defoliation first appears in the stand. Douglas-fir tussock moth outbreaks occur suddenly and are generally characterized by a sequence of four phases (release, peak, decline, post-decline, Figure 4.), each lasting about one year (Wickman et al., 1973; Mason and Wickman, 1991). In the release phase, larval populations increase from low, non-damaging, difficult to detect, levels to sub-outbreak densities. Defoliation is generally not detectable from the air and is restricted to light feeding in the upper third of the crown evident from the ground in the fall. Large egg masses are locally abundant. During the peak phase, larval populations are high and defoliation is more severe and easily visible from the air. Most outbreaks have been first

detected during the peak phase. Larval survival is usually good and new egg masses are again numerous in the fall. The decline phase is characterized by high initial larval populations that decline significantly due to natural factors (e.g., nuclear polyhedrosis virus; starvation) prior to pupation. Although populations are declining, this phase typically results in some additional defoliation to host trees. This is the phase that has generally been targeted for suppression. The poor larval survival results in few new egg masses produced in the fall. In the post-decline phase, there is little to no additional defoliation and populations return to low, non-damaging levels that are difficult to detect.

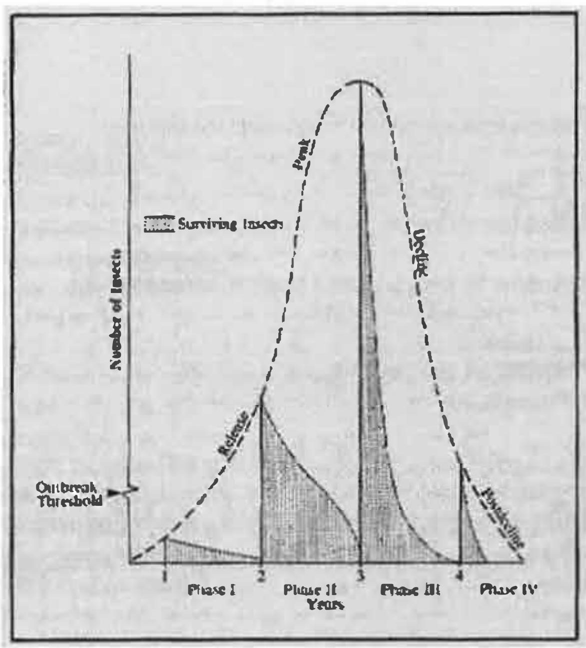

Figure 4. Schematic representation of an outbreak.

Impact/Ecological Considerations

To understand the impact DFTM has on trees and stands, it is important to have knowledge of its role within a forest ecosystem. In all ecosystems every level of the food chain is important. The DFTM, as with other phytophagous insects, contributes to the stability of forest ecosystems through its effects on tree growth, survival, and forest succession (Mason & Wickman 1984). The impact of DFTM on a stand depends upon the management objectives or goals for that particular stand. Short and long-term effects caused by population outbreaks do not always have negative implications. Populations infrequently reach outbreak levels and when they do, they do not remain at high levels. Damaged caused by DFTM was studied in white fir stands in California (Wickman 1963). Data were collected from the infestation on the Stanislaus National Forest during 1954-1956 and the infestation on the Inyo National Forest during 1934-1938. Wickman found that mortality of white fir was caused by defoliation alone and by a combination of defoliation and fir engraver beetle attacks. In the most heavily defoliated stands, 20% of the saw timber volume died within 5 years following the end of the Stanislaus outbreak. Similar results were obtained following the outbreak on the Inyo where 29% of the volume was killed

within 5 years. Top damage in the Stanislaus infestation was most severe in the heavily defoliated trees, 12% of them being top-killed as a result of DFTM feeding. Radial growth loss was most pronounced and similar for both infestations. The loss of radial growth was most notable in trees more than 30% defoliated. Defoliation had an immediate effect upon white fir growth, and when feeding stopped, growth increased immediately.

From data on tree mortality, top kill, and stand development, gathered following outbreaks, Wickman (1978a) concluded that there was a consistent relationship between degree of defoliation and the amount of damage to Douglas-fir and grand-fir. Furthermore, for the data gathered on mortality, he indicated that 90% of the trees that died had been defoliated 90% or more. Trees defoliated 50-75% rarely died from defoliation. He observed that over half of the mortality occurred in patches that made up a small proportion of the outbreak area. Top-kill of trees, as noted above, is frequently associated with DFTM outbreaks. Top-kill damage was examined by Wickman (1978c) continuously during the outbreak in the Blue Mountains in north-eastern Washington and Oregon in the early 1970's. The incidence of top-kill in heavily defoliated stands in the Blue Mountains during the 1970s was 35%, 12% in moderately defoliated, and in lightly defoliated stands incidence of top-kill was 5% (Wickman 1978c).

Outbreaks cause short and long-term changes in stand development. Both radial and height growth for trees are sharply reduced during and immediately following an outbreak (Mason & Wickman 1984). Growth reduction is proportional to the amount of defoliation and most pronounced in trees defoliated 50% or more (Wickman et. al. 1980). However, growth usually returns to pre-outbreak levels within 5 years and after 10 years may surpass pre-outbreak growth rates (Wickman 1978b). Enhanced growth appears to be the result of increased nutrient cycling, brought about by defoliation and the lower stocking levels resulting from tree mortality (Mason & Wickman 1984).

Conditions and habitats that are prone to DFTM outbreaks have been identified. Infestations often occur in seral stage communities and forested-grassland ecotones, where sites are marginal for the growth of fir, and except for fire exclusion and selective logging, are normally dominated by pine or are not forested (Wickman 1978a, Williams et. al. 1980). As mentioned previously, white fir is the preferred host species in California. Many mixed conifer stands have an unnaturally high component of white fir as a result of logging practices that selectively removed the more economically valuable pine species. The results of selective harvest systems and high-grade logging have increased stand hazard conditions to DFTM defoliation by favoring regeneration of host species (Stoszek 1978). Also, fire suppression policies have largely excluded fire from these stands. This encourages the less fire resistant and more shade tolerant white fir. These management practices have combined to increase availability of white fir foliage suitable for DFTM population increases and outbreaks.

Site and stand characteristics in areas where outbreaks have occurred provide further information about the habitat types that are prone to DFTM outbreaks. Wenz and his coworkers (1977 unpubl.) compared site and stand characteristics on 66 plots on the Modoc, Eldorado and Stanislaus National Forests where DFTM outbreaks were known to have occurred, to characteristics of 67 plots in the same general areas that had no records of outbreaks. They found that outbreaks occurred in stands located on ridgetops of upper slopes and on poorer sites.

Stands where outbreaks had occurred also tended to have a lower stand density, particularly of white fir, less crown cover, shorter upper story trees, and less vertical diversity than stands without an outbreak history.

Monitoring Results

1) Early Warning Pheromone Monitoring System. The early warning pheromone trapping system is used in California and west-wide to detect DFTM. This survey system is primarily a management tool for focusing attention on potential increasing populations. The system was designed to provide an index of population changes of the moth and make it easier to identify areas building toward outbreak populations. A detailed description of the early warning system can be found in U.S.D.A. Agricultural Handbook 546 (Daterman et al. 1979). An average of 25 moths/trap/plot or more can indicate that the local population is approaching the outbreak stage. It is important to realize that this threshold (25 moths/trap/plot) is used to depict increasing population trends. It is not an absolute number which always indicates a future outbreak and subsequent resource damage. When average trap catch per plot reaches this level, survey efforts should be intensified in the area by employing additional sampling techniques (Mason 1979).

The DFTM early warning trapping system was initiated on the Modoc National Forest in 1980. Additional plots (3) were added on the Big Valley Ranger District in 1982-1983 and three more plots were added in the defoliated areas in 1999.

Warner Mountain Ranger District - 2 plots
Big Valley Ranger District - 10 plots
Devils Garden Ranger District - 2 plots

Until this recent outbreak no reports of DFTM defoliation had been reported on the Modoc National Forest since the trapping program began. Tables 2 & 3 contain the trapping data for the Modoc National Forest and California Department of Forestry and Fire Protection plots for 1980-1999. In the two plots on the Warner Mountain Ranger District, the highest recorded average trap catch is 22.4 moths/trap, which occurred in 1996 on the Stough plot. Trapping data from the Devils Garden Ranger District also indicates fluctuating population levels over the years for both plots. The average number of moths/trap/plot exceeded the threshold level (>25, thought to indicate the possibility of an outbreak) in the Meteorite plot in 1992, however, no defolation was reported and traps counts have remained low since then. Two plots monitored by California Department of Forestry and Fire Protection (CDFFP) personnel are located about 6 miles west of Goose Lake. Trap counts in the Goose Lake plots exceeded an average of 25 males/trap per plot during 1992 and 1995 but counts dropped the following year and no defoliation was reported.

Trapping data from the Big Valley Ranger District also indicates that populations have fluctuated up and down between years and plot locations. Most years of increasing trap catches have been followed by few or no moths caught the next year. There was a increasing trend in some plots between 1990 and 1991; however, no defolation was reported and traps counts had remained low through 1998. The average traps counts for all plots on the Big Valley RD exceeded 25 moths/trap for 1998. Six of the seven plots for the District are located within 3 miles of the area infested during 1999 and the remaining plot is located about 7.5 miles west of the outbreak area. In addition, CDFFP plots are located in the Calpines area and one near Hilton. The Calpines plot

is located within the area defoliated during 1999 (see attached maps) and the Hilton plot is about 3 miles southeast of the infested area. Average trap counts for the Calpines plot have never exceeded an average of 25 moths per trap, even during 1998, the year prior to the defoliation. The average trap count did show an increase from 1997 (5.5 moths in 1997 to 22.2 moths in 1998) to 1998. Data from the Hilton plot indicates low populations levels from 1988, when the plot was installed, through 1999. Similar to the Calpines plot, the average trap count showed an increase from 1997 (5.0 moths in 1997 to 53.2 moths in 1998) to 1998. All average trap counts except for two plots (Horsehead 1 & 2) returned to below threshold levels for 1999.

Historically, National Forests in northeastern California as well as those areas monitored by CDFFP have shown a significant increase in DFTM trap counts in one year followed by very low traps counts and no or low levels of defoliation the following year. Don Owen, CDFFP entomologist and myself expected the same to be true for the sudden one year increase in trap catches in 1998 on the Modoc National Forest and for areas monitored by CDFFP. As we discovered that was not the case this time. The average trap catch of 25 moths or more in 1998 did, in this case, indicate that the local populations were approaching the outbreak stage, which apparently peaked in 1999 (see egg mass monitoring below). Survey efforts will be intensified in the future following high trap counts. The life stage that would have been sampled would have been the larval stage in the spring and early summer of 1999. Larval populations are monitored using a technique known as lower crown beating (Mason; 1979). It involves knocking early stage DFTM larvae from the lower crown branches of the host onto a drop cloth. The proportion of trees infested is converted to an estimated mid-crown density expressed as the number of DFTM larvae per 0.64 sq. m. (1000 sq. in.) of foliage. Tussock moth defoliation usally becomes conspicuous at about 20 early stage larvae/0.64 sq. m.

FPM, in conjuction with research personnel are testing and evaluating various different trap deployment and configuration systems. This work is directed at providing DFTM population data over more acres without sgnificantly increasing the time required for trap deployment and monitoring or in the costs associated with trapping.

2) Egg mass monitoring. As a result of the defoliation, an egg mass survey was conducted to assist in predicting population levels for 2000 in the defoliated and surrounding areas. We used a sequential egg mass sampling system based on visually scanning the lower branches of the host trees for egg masses and counting the total number of egg masses on three lower branches per tree (Shepherd & Otvos; 1984). Don Owen, myself and several of the Modoc NF employees conducted egg mass surveys in the defoliated and surrounding areas November 8-10, 1999. Twenty trees per plot and five plots in each of the three outbreak areas were sampled. Although some egg masses from the prior year were observed, no new egg masses from the 1999 populations were seen. Based on this information, the outbreak declined due to natural factors and defoliation is not expected in this area this season.

Egg masses were also monitored during 1999 using a technique which utilizes artificial pupation shelters (Dahlsten et. al. 1992). The artificial shelters are 10 x 9 x 4 cm wooden blocks with four 2.5 cm holes drilled in them. The shelters are attached to the bole of host white fir (2 shelters/ tree). Larvae will sometimes use the holes as a pupation site. Egg masses and female pupae in the shelters have been significantly correlated with the following year's larval counts (Dahlsten et. al. 1992).

Shelters were placed on the trees after defoliation was detected in 1999 to assist with predicting population levels for 2000 and to provide some known locations of egg masses to monitor hatch. Modoc NF personnel installed and monitored the shelters. Five plots were installed throughout the defoliated areas using 10 trees per plot. Similar to the results of the lower branch sampling, no egg masses were found in any of the artificial shelters.

3) Cocoon Sampling. Cocoons were collected off of the same branches that were visually examined for egg masses. With cocoon sampling, however, only 18 inches of the branch tips were examined compared to whole branches for the egg masses. Cocoon sampling is an additional technique that is used in some areas to predict larval density for the next generation (Mason et. al. 1993). Because we were already sampling for egg masses Don Owen and I decided to count and collect the cocoons at the same time. All cocoons within 18 inches of the branch tips were collected without distinguishing between new and prior year cocoons so there was a combination of 1998 and 1999 cocoons. The combined counts for the 300 sample trees totalled 741 cocoons. Of these, 734 were examined in the lab to determine the percentage of pupal mortality. Mortality can result from predation, parasitization, or developmental failures (Torgerson 1978). Eighty-two percent of the cocoons contained non-emerged pupae. This data supports the inability to find egg masses and the conclusion that the outbreak collasped in 1999 due to natural causes. It also points out that although cocoons may be numerous in a stand, subsequent sampling of other life stages is important to accurately predict population levels the following year.

4) Monitoring of Defoliated Trees. Permanent plots consisting of individual trees (10 plots/5 trees per plot) were installed throughout the outbreak area to monitor the effect of defoliation. Defoliation levels can be used to predict both direct and indirect tree mortality and top-kill (Wickman 1978a). Trees were tagged, diameters were recorded and visual estimates of percent of defoliation were taken. Tree condition was also documented using color slide photography. Trees will be monitored in 2000 and subsequent years if needed to provide site specific information relating tree mortality and/or top-kill to degree of defoliation.

Conclusion

Historically, DFTM outbreaks in western North America have appeared to be synchronous, particularly in Washington, Oregon, northern Idaho and British Columbia (Shepherd et. al. 1988). Populations tend to increase to outbreak levels and collaspe in a variable cycle that averages about 10 years between peaks. Since the 1950's, there has been one DFTM outbreak in California each decade. During the 1990's two outbreaks were observed in separate locations: in Sequoia-Kings Canyon National Park and Sequoia National Forest in 1998 and the one discussed in detail above on the Modoc National Forest in 1999.

Information obtained from trapping data combined with outbreak history indicates that populations (average trap counts) can increase and then decline before reaching outbreak levels, can follow the generalized pattern of the outbreak sequence (Figure 4.), or can increase to outbreak level and then collaspe in a more condensed period. Mason and Luck (1978) speculate that a buildup over a 2-3 year period is probably the precursor for most population releases. If that was the case on the Modoc, it certainly was not detected by increases in average trap catches over a 2-3 year period prior to the outbreak. The peak in average trap catches occurred one year before defolation was detected and declined to low levels the same year the defolation occurred.

Although defoliation in the outbreak areas is not anticipated for 2000, it is appropriate to continue population monitoring (early warning trapping system and artificial shelters) and to continue to look for DFTM feeding and defoliation on the Modoc National Forest. Susceptible areas, based on past outbreaks, include ridgetops of upper slopes and on poorer sites. Susceptible stands also tended to have a lower stand density, particularly of white fir, less crown cover, shorter upper story trees, and less vertical diversity than stands without an outbreak history. In 2000, Forest Pest Management will conduct larval sampling in and around the two plots (Horsehead 1& 2) that had above threshold values for average trap catch and also monitor the defoliated trees in the permanent plots. Additional reports will be generated as needed.

If you have any questions, please call me at 530-252-6667. If District personnel would like to establish additional trapping plots, please let me know so I can respond accordingly when the materials are mailed out.

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Figure Credits:

Figure 1. Egg mass and larvae. In: Forest Insect and Disease Leaflet 86. Wickman, B.E., R.R. Mason & G.C. Trostle. 1981. p. 1. U.S. Department of Agriculture Forest Service.

Figure 2. Mature larva. In: Forest Insect and Disease Leaflet 86. Wickman, B.E., R.R. Mason & G.C. Trostle. 1981. p. 5. U.S. Department of Agriculture Forest Service.

Figure 3. Adult male. In: Forest Insect and Disease Leaflet 86. Wickman, B.E., R.R. Mason & G.C. Trostle. 1981. p. 5. U.S. Department of Agriculture Forest Service.

Figure 4. Schematic representation of an outbreak. In: The Douglas-fir tussock moth: a synthesis. p. 44. M. Brookes, R.W. Stark, and R.W. Campbell. eds. U.S.D.A. Tech. Bull. 1585. 331p.

Table 1. The location, duration and size of major DFTM outbreaks in California since 1935.

Years	Location (County)	Acres of Defoliation
1935-1937	Mono	15,000 acres
1954-1956	Calaveras, Tuolumne	11,000 acres
1963-1965	Modoc, Plumas, Lassen, El Dorado	78,000 acres
1970-1972	Amador, Calaveras, El Dorado, Fresno, Madera, Mariposa, Shasta, Tulare, Tuolumne	100,000+ acres
1987-1989	Lassen, Plumas, Sierra, Tehama	105,000 acres
1998	Fresno, Tulare	44,000 acres
1999	Modoc	2,200 acres

Table 2. Mean Douglas-fir Tussock ~~Moth~~ Pheromone Trap Catches for Modoc Locations, 1980 - 1989.

Location	Plot Name	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Modoc National Forest Plots											
Warner Mtn.	Stough	0	11.8	0.2	0	2.8	0	0.6	0.8	1.8	0
	Parker Creek	0	1.2	0	0	6.2	0.2	0.2	0.8	2	1.6
Big Valley	Johnson Sp. 1			4.4	3.6	22.4		**25.8**	4.4	22.2	0.2
	Johnson Sp. 2			1.4	0	4.8		4	1.6	**38.2**	0
	Niles				0	5.8		15.6	1	**26**	0.4
	Horsehead 1	0	7	0.8	0.6	14.8		8.8	3.8	**28.6**	9
	Horsehead 2	0.2	**28.6**	0.8	0	19		**25.4**	2	**38.2**	1.2
	Hunter 1	0.4		1.4	0	4.8		2	0	16.6	0
	~~Hunter 2~~	0	2.2	0.6	0	1.4		0	0.2	~~29.6~~	0
	Hunter 3										
	Hunter 4										
	Deer Spring										
Devils Garden	Meteorite	0.6	19.4	2	0.8	9	1.4	15.4	7.8	12.2	8.6
	Grouse	4	16.2	2	0.4	5	0.8	15.4	6.6	18.2	12.4
CDFFP Plots	Goose Lake	0	14.2	0.8	0	7.3	4.4	9.8	13	3	0.8
	Dry Creek Rim									1.2	0
	Ashley	0	0.6	0	0.2	8	1.4	6.6	4	1.8	0
	Sportsman									7.4	0

*Bold numbers denote an average of >25 moths per trap for the plot.

Table 3. Mean Douglas-fir Tussock Moth Pheromone Trap Catches for Modoc Locations, 1990 - 1999.

Location	Plot Name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Modoc National Forest Plots											
Warner Mtn.	Stough	0	0	0.2	0	9.6	12.8	22.4	3.2	213	1.2
	Parker Creek	0	0	0	0	0.2	1.6	5.2	0.8	6.3	0.6
Big Valley	Johnson Sp. 1	**33.4**	**36.6**	0.8	0	0.8	6.2	1.6	1.2	**43.8**	9.2
	Johnson Sp. 2	3.6	14.6	0	0	0.2	6.6	4	2.8	**35.6**	8.8
	Niles	9.6	22.3	0.4	0	0.4	12	3.8	1.4	**48.4**	18
	Horsehead 1	4.2	37	0.4	0	1	20	5.8	2.4	**38.2**	**25**
	Horsehead 2	26	**43.6**	0.4	0	2.8	11.4	16	7	**71.6**	**33.4**
	Hunter 1	1.8	3.2	0.6	0	0	10.8	2.8	5.2	**53.2**	16.6
	Hunter 2	1.6	4.6	0	0	0	2.2	10.5	3	**44**	10.2
	Hunter 3										7
	Hunter 4										19
	Deer Spring										19.6
Devils Garden	Meteorite	15.2	1	32	5.2	0.6	1.6	5.8	0		0
	Grouse	0.8	8.8	1.4	0	1	1.6	9.4	0	0	1.8
CDFFP Plots	Goose Lake	6.4	3	**55.6**	4	2.6	28	11.2	0.2	1.8	1.2
	Dry Creek Rim	1 2	0.8	**65.6**	3.2	5.8	**36.5**	11	0	3.2	1.2
	Ashley	0.2	8.8	5.2	0	0.2	9	16	5.5	22.2	10.8
	Sportsman	0	0.8	17.8	0	2.2	12.8	18.2	5	**53.2**	24.6

*Bold numbers denote an average of >25 moths per trap for the plot.

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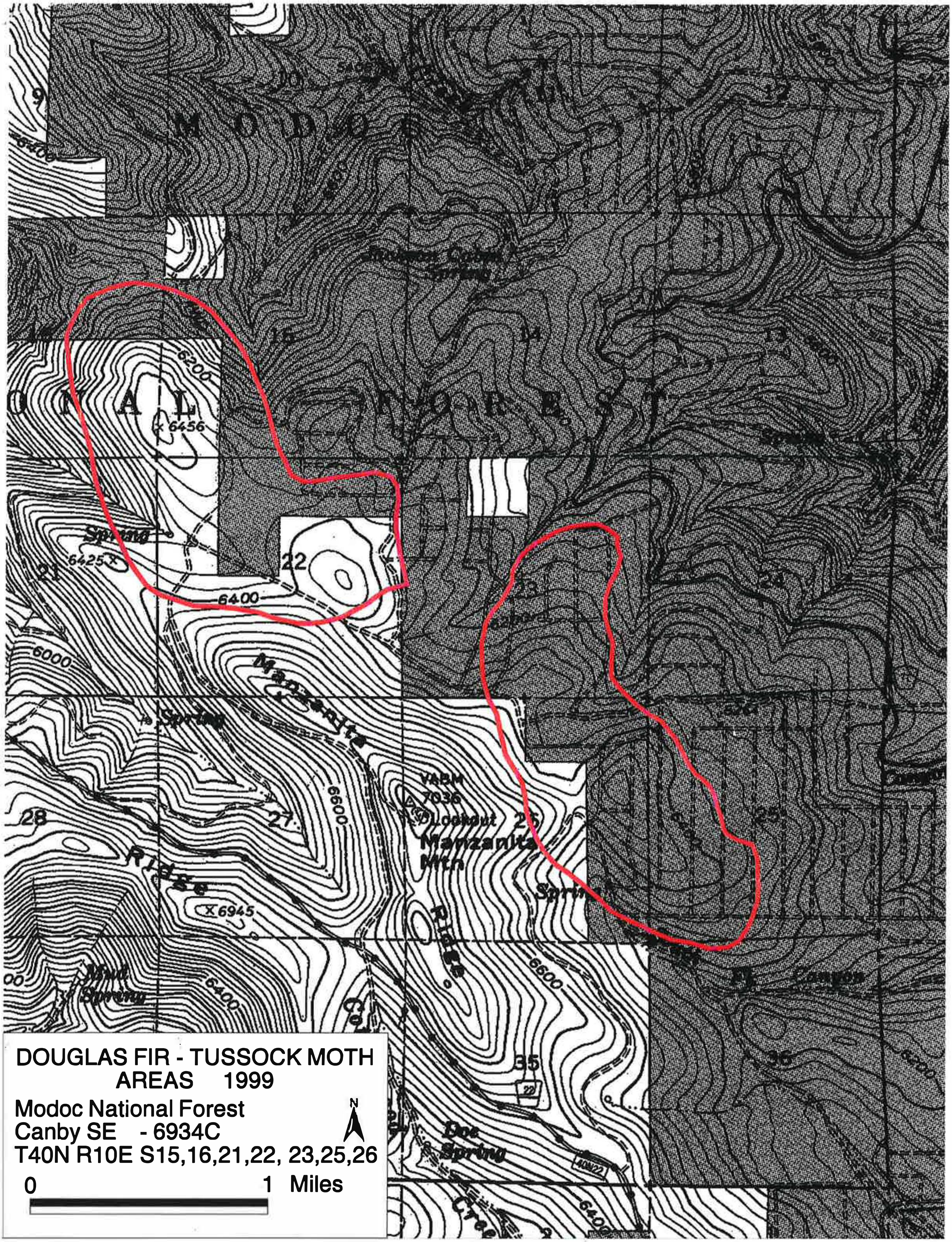
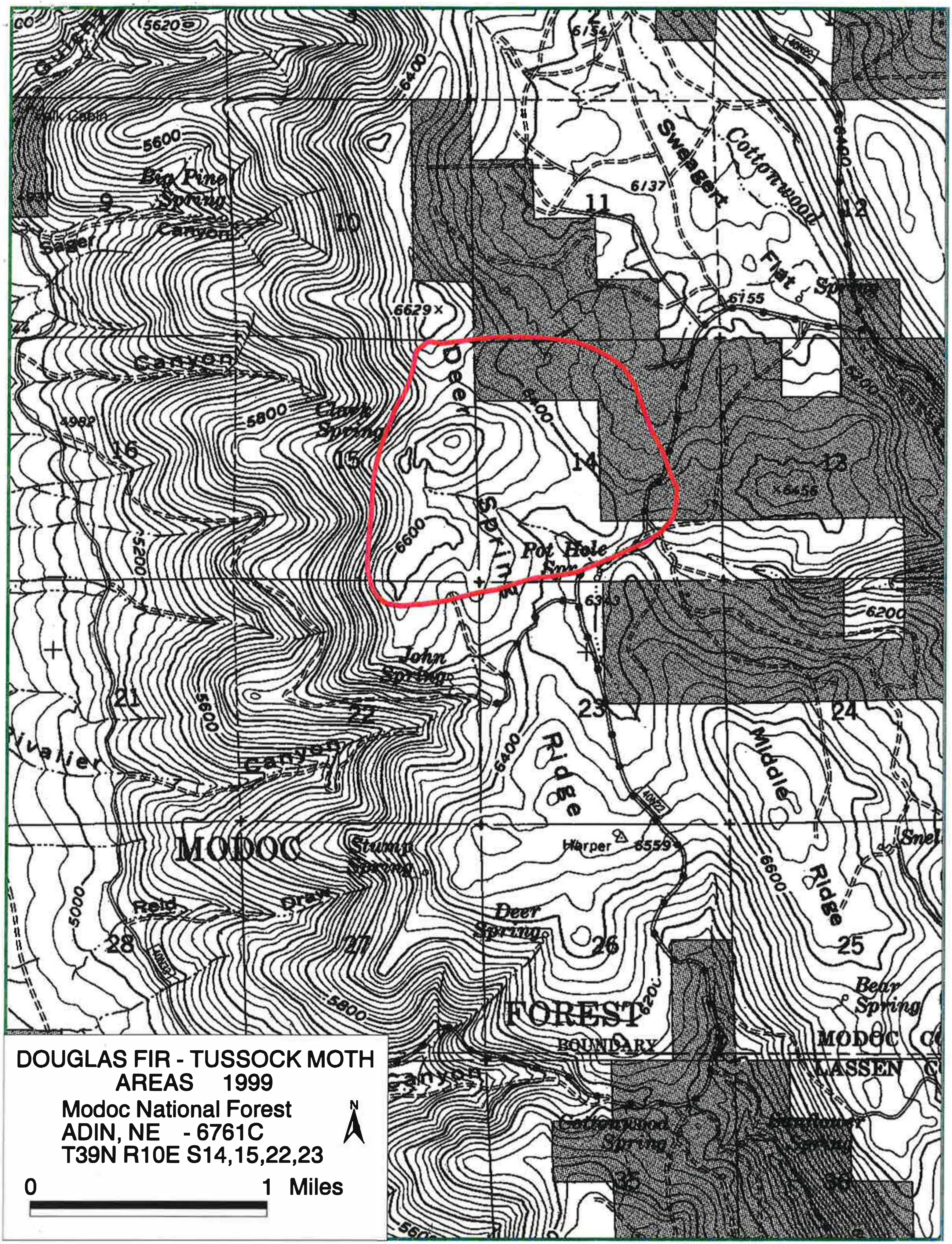

DOUGLAS FIR - TUSSOCK MOTH
AREAS 1999
Modoc National Forest
Canby SE - 6934C
T40N R10E S15,16,21,22, 23,25,26
0
1 Miles
N
M O D O C
O N A L
F O R E S T
6456
6200
Spring
6425
21
22
6400
6000
Manzanita
6600
VABM
7036
Lookout
Manzanita
Mtn
Ridge
6945
28
27
Mud
Spring
Doe
Spring
35
36
24
25
23
16
15
14
13
12
10
9
Canyon


DOUGLAS FIR - TUSSOCK MOTH
AREAS 1999
Modoc National Forest
ADIN, NE - 6761C
T39N R10E S14,15,22,23
0
1 Miles
N
Big Pine Spring
Sager Canyon
Canyon
Clark Spring
Deer Spring
Pot Hole Spr
John Spring
Swagert
Cottonwood
Flat
Spring
Ridge
Middle
Ridge
Canyon
MODOC
Stump Spring
Reid
Draw
Harper
6559
Deer Spring
FOREST
BOUNDARY
Bear Spring
MODOC
LASSEN
Cottonwood Spring
6629
6155
6137
6343
5600
5800
6400
6600
6200